ON STIMULUS IN THE ECONOMIC LIFE

By

SIR JOSIAH STAMP
G.B.E.

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By

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ON STIMULUS IN THE ECONOMIC LIFE

(1) *The Idea of Stimulus in Economic Life.*

There is no term in more constant use in current discussion of our economic life and its direction than "stimulus," loosely employed to serve various distinct meanings. We hear of a change in the Bank Rate stimulating trade, of a reduction in the Income Tax stimulating enterprise, of an increase in piece rates as a stimulus to the worker's output, of some share in profits being required to act as a stimulus to labour interest, of rising prices as a stimulus to business. Indeed, nearly every change in economic factors is, or can be, reduced to terms of stimulus (or its converse) to existing conditions. Locarno or the latest news from China may "stimulate" the Stock markets. Static economic conditions do not interest us today nearly so much as dynamic changes and their effects. I have chosen the word "stimulus" rather than "incentive" because incentive is too closely akin to motive, and it is essentially the change in the *degree* of incentive, the *increment* in incentive, that I wish to examine. It plunges deep into the physiological and psychological nature of man, into the physical nature of matter, and into the profound interactions of these three. No specific examination of the action of stimulus, abstracted from its particular manifestations, has to my knowledge been made. Within the limits of a Rede lecture I cannot make it; all I can do is, in the words of Bacon, to tinkle a bell "to call the wits together." All I can do is to throw out some of the essentials of an enquiry, which is not so much something to be independently undertaken, as a feature to be watched and noted in the course of general economic study. Only the catholic interpretation of this Rede foundation could possibly admit a lecture so greatly deviating from its main type. But in 1893 Sir Michael Foster addressed himself to "Weariness" and a few years before Sir Francis Galton spoke upon the "Measurement of Human Faculty," both of which subjects lie upon the confines of my own.

First then, "Stimulus" must be carefully distinguished from incentive and enlarged scope. Incentive may exist ample to take full advantage of the whole range of possibility that conditions allow. If conditions are made wider or easier, the same unaltered incentive may serve to achieve larger results, and no increase in that incentive is required —no stimulus to increased or intenser action. There is more confusion of thought upon this distinction than almost any other. A lower rate of general interest is popularly supposed to be good for business, and make for more enterprise. But it does not do so necessarily by stimulating or inducing greater energy or risktaking. Let us suppose that the cream of new enterprise (or extension of existing business) is so advantageous an improvement upon existing methods as to promise a definite advantage which will yield 20 per cent. upon the capital involved. This class of enterprise will be undertaken whatever the current rate of general interest, for it obviously affords an ample margin. There will be a downward gradation extending in number or magnitude. Thus those offering advantages of 10 per cent. may be twice as numerous; those with 7½ per cent. four times; those with 6 per cent. eight times; 5 per cent. twenty times; 4 per cent. a hundred times; 2 per cent. five hundred times, and 1 per cent. a thousand times as many. The chief way in which interest on capital is produced is when capital invested in fixed forms, by a roundabout or delayed method, supplies more commodities than a direct or immediate method, and the surplus, or advantage, if large, is a source from which high interest can be paid; if the new method is only just a bare improvement the interest must be small.

These unborn opportunities for business men are mutely making bids for any capital that is offering. The richest openings make the highest bids, and thus become objective realities. If no capital is willing to come forward for less than 10 per cent. all those very numerous "one talented" possibilities that could not afford or produce 10 per cent., remain unborn. If capital offers at 5 per cent., an immensely larger number become alive, but there is always a considerable field of untapped potentiality below the current rate. Suppose a company to be the owner of a number of tin mining propositions of varying degrees of richness of yield, so that if tin is £150 per ton, it will pay to work only one, but if tin is £300 per ton, it will pay to work them all. The purpose of this company is to make all the money it can—

all that conditions will allow it to make. This *incentive* is just as great whether two mines or ten are possible. The change in the price of tin is not strictly a stimulus to greater production; it is an automatic enlargement of scope within which the same incentive may work. A lower general rate of interest is an automatic enlargement of scope. The water flows automatically into the new conduits without increased pressure. (It may indeed have, in addition, psychological influences upon willingness to work, or save, which may be true stimulants, and this we must examine later.) The supply of capital however, in relation to the rate of interest obtainable, is also graded, but in the opposite direction, at any particular time. Although there are certain kinds of savings which tend to be greater if interest is low, and certain kinds which tend to be indifferent to the rate, still, taken on balance and as a whole, at any given moment, if interest offered is high the total capital supply evoked is larger than if the rate is low. In so far as saving is the result of abstention from spending, which is made worth while by the reward or price, many people would not deny themselves present pleasures of spending for a return of only 2 per cent., but they would do so gladly for 15 per cent. Thus the capital *demanded* by ventures which could make 2 per cent. or more would be very large, but the capital offered at 2 per cent. would be very small. Similarly the capital offered for 20 per cent. would be very large, but the number of ventures that could pay it are few and the capital actually changing hands at this rate would be therefore relatively small. At some intermediate point there is a rate of interest at which the amount of capital people will offer for such a rate (or a higher but not lower rate) is equal to the amount of capital demanded by businesses which can reckon to produce that rate or more. That equation of amounts automatically determines the rate. And if openings for business never varied in their gradations of possibilities, and if the motives and opportunities for saving capital never changed, that rate would not change. If something happens on the side of the supply of capital—something affecting people's willingness to save—so that a much larger amount, say 20,000X, can be offered at the old rate of 5 per cent., instead of 10,000X, and 15,000X is offered at $4\frac{1}{2}$ per cent. and 10,000X is offered at 4 per cent., then the equation with the old scale of opportunities is found at a new point. Suppose the scale is as follows:

Businesses which could produce

6	per cent.	or more	would take	5,000X	capital.
5	,,	,,	,,	10,000X	,,
$4\frac{1}{2}$	,,	,,	,,	15,000X	,,
4	,,	,,	,,	20,000X	,,

Then the change in the supply of capital brings about an equation with demand at $4\frac{1}{2}$ per cent. which becomes the new normal rate. Thus if the rate goes down, the scope of business is automatically enlarged. But the rate may go down (or the supply be increased at a given rate) automatically or as a result of some special stimulus to saving. So when we say "if the rate were lower it would stimulate business" we are putting the stress in the wrong place, and we could more accurately say "if some cause could be found to stimulate a greater supply of capital at given rates (or the same supply at a lower rate) more business would be physically possible." It becomes a matter of importance then to consider the motives under which saving takes place, and particularly how a change or increment in incentive changes the saving.

But it is not to be supposed that the other side—the potentiality or offer for capital—

remains unchanged. Research, invention or discovery may alter the whole gradation, or open up new potentialities which increase the number of businesses that could produce X per cent. or over, and therefore the total capital demanded at X per cent. The love of adventure, the microbe of scientific curiosity, the desire for fame, may be in the aggregate a constant incentive, and the supply of these ingredients may be in regular undisturbed operation in the economic sphere, keeping the gradation to which I have referred at a regular or constant level. But if a sudden increase in worldly honours, or in popular appreciation attaching to a life of success in research, increased the numbers of those turning to this life, or could conceivably redouble the efforts of those already devoted to such a life, the flow of this ingredient in human progress might be enlarged, and the gradation of potential "offers" for capital completely lifted or altered. In this case the rate of interest might again be changed as the automatic result of a new equation between an unaltered range of capital "supply" at particular rates and an altered range of capital "demand" at particular rates. It is often quite elliptical to say that business is "stimulated" where the scope of business follows automatically or arithmetically upon the ruling conditions. Stimulus may indeed be operative somewhere in modifying one of those conditions, but those conditions are constantly altering without conscious stimulus being responsible.

Take the case of a goat tethered by a 20 feet rope to a pole in a field. Within the scope thus afforded it finds its sustenance. Let it be assumed that the feeling of satisfaction when it will lie down and cease to eat is the result of obtaining a definite quantity of food. Then if it obtains that easily and quickly it will work for a shorter time than if the crop is sparse and mean. To lengthen the rope to 40 feet will not change this "incentive" and it is no stimulus, but only an enlargement of scope, which may or may not result in shorter hours according to the comparative richness of the old and the new areas. But suppose that working within the original circle the goat could not really "satisfy" itself physically, using all its time, and remained tired and under-nourished. Then the lengthening of the rope is once more only enlargement of the scope within which the existing and potential incentive can be satisfied. It is no change in that incentive, and no real stimulant. Unless indeed from scraping for a living the sudden change to lush grasses easily obtained tempts the goat to over-indulgence, and a change in the definite quantity of food required. This stimulus may make a permanent change in habit. It may be merely temporary.

Again we must distinguish stimulus, as an increment in incentive, from a mere "shake" which gives the opportunity or occasion for the realisation of a scope that is already existent. This is a sense in which the word is often used. For example, it has been said by the economist in the long discussion between the "economic" and business views on the incidence of income tax, that it is economically impossible to add the tax to existing prices, though where, through custom or inertia, existing prices for particular things are not as high as they might be forced, the tax will act as a goad to discover the hitherto unfound areas of potential increase. That is, many a "stimulus" merely shakes the frictionary elements out of the existing situation, and oils things into their true places.

Again, we must consider the stimulus which supplies no energy but promotes the release of such energy as exists latent, like a detonator, or a catalyst in a chemical process, as distinct from something which is a real addition to the other agents, such as many types of fertilisers. In so far as stimulus supplies only release and not fresh energy, it may be said to imply the ideas of reaction and of exhaustion, for it may have provoked only the using up of a stock, or at least some taking from the stock which may or may not be renewable.

Of what order or orders is stimulus in the economic life?

(2) *A Provisional Classification of Stimulus according to its Results.*

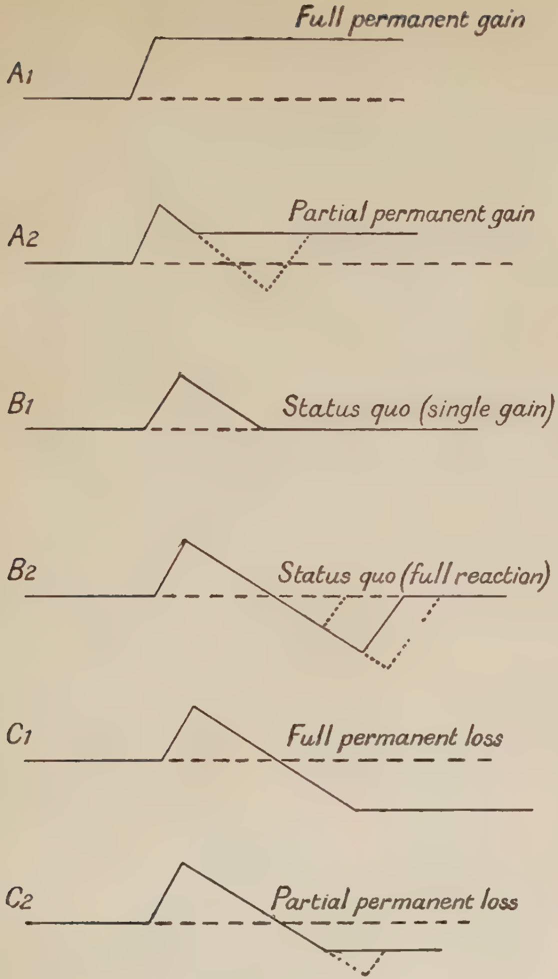
It will be of assistance, before setting out on an enquiry, to classify the chief possibilities, on abstract considerations, of the results of stimulus. The classification will serve as a means of test, and of record.

If we view the normal working of natural forces as a straight line, with or without a growth "trend" (or as a wavy line with rhythmical fluctuation), we may set down the different conceivable consequences of "lifting it" artificially by a stimulus in three main classes. Let us take the results of a single application of stimulant. It may be permanently lifted in achievement, with or without subsequent loss, then following a course parallel to its old course. This may happen to the full extent to which it is urged, or it may sink back partially, after reaction of varying extent. This class A we may call the *Permanent Gain*, Full (A 1) or Partial (A 2) as the case may be.

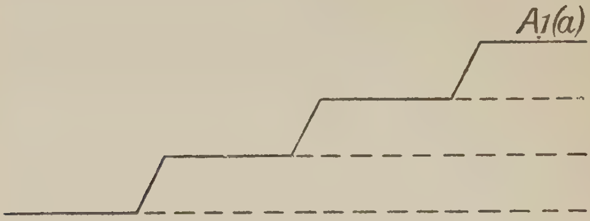
It may lose the effect and gradually sink back to its normal line, pursuing its old course. In this case the gain is limited. Or it may, before resuming its original course, react below the normal for a time and thus lose all or part of the special gain. This I will call the *status quo* class, B 1 a single gain, and B 2 full reaction.

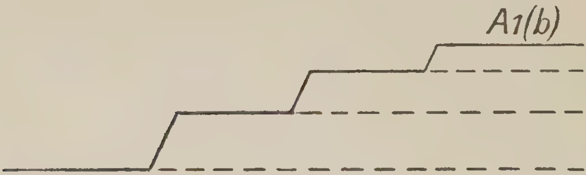
The third class, C, is the converse of A, for the reaction is such that the line of effect is resumed below the normal, to a greater or less extent—*Permanent Loss*, full or partial.

If we now consider the possible effects of repetitive "doses" at intervals of time, something depends upon whether the interval is so short that the results in A are not fully effective. Such repetitive doses may be constant, diminishing, or increasing


Full permanent gain
A1
Partial permanent gain
A2
B1
Status quo (single gain)
B2
Status quo (full reaction)
C1
Full permanent loss
C2
Partial permanent loss

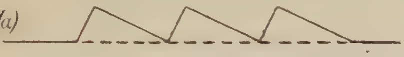
(or cumulative) in quantitative effect. They may leave a permanent strengthening or permanent weakening of potentiality for development after the doses cease. The first two of these three forms applied to A are pictured thus:



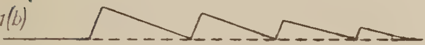


B will present a series of constant wave motions either of equal amplitude (B 1 (*a*) and B 2 (*a*)) or of diminishing and increasing amplitude (*vide* B 1 (*b*) and B 2 (*b*) as examples of the diminishing order). Now we may suspect that the changes brought about by stimulus in different fields of experimentation can be subsumed under one or other of these categories.

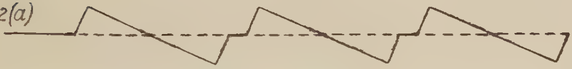
B1(a)



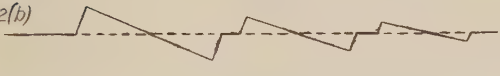
B1(b)



B2(a)



B2(b)



(3) *The Different Factors of Economic Life.*

The economic life is a complex reaction between a physical world, obeying the laws of physics and chemistry, and living organisms obeying more elusive biological and physiological principles, the whole relationship being worked upon by individual and mass psychological and "spiritual" forces.

No one can say which factor is dominant in every movement for a change from the economic *status quo*, though the factor of motive seems to be the controlling variable in many measurable instances. But it may be that the inertia of the other elements, or their familiar laws, can have an inevitable effect on the human qualities. Thus if motive were stimulated into doubled action it might conceivably retain that force indefinitely, were it not for the fact that the physiological or physical adjuncts through which alone motive can be objectively realised have been flogged into unwonted activity, are subject to complete reactions, and pull down the motive or incentive with them. The spirit may be willing but the flesh weak.

If the economic life is a complex of these three worlds of law, we may hope to learn something of the laws of stimulus by studying them separately in each sphere, either to look for some analogy, or to find the influence of the "ingredient" directly present in the final mixture. It is worth while, therefore, to scan our knowledge in the fields of physics, chemistry, physiology and elsewhere where stimulus may conceivably be observable and measurable. Moreover, we may thus attempt to make an abstraction of the idea of stimulus. Professor Whitehead says that "the utmost abstractions are the true weapons with which to control our thought of concrete fact[1]."

Two biological laws governing the relationship between a cell and an external stimulus acting upon it, rather tend to prevent good generalisations of a quantitative character. They are to the effect that one and the same stimulus will evoke different responses

(i) not only from the same cell under different conditions, but
(ii) also from different kinds of cell under the same conditions[2].

(4) *The Stimulus of Drugs—an analogy.*

It is a commonplace of the popular theory of drug stimulus that to secure a constant reaction with a succession of doses the amount of the dose must be increased, or alternatively, that a constant dose is succeeded by a continuously diminishing reaction. It is the former aspect which is generally included under the description of "tolerance." While the literature of the subject abounds in broad indications along these lines, and many qualifications and exceptions, no exact quantitative tests have been made which could be reduced to a definite relationship expressible in a formula or curve. Enquiries from many physiologists and pharmacologists have failed to elicit anything approaching even an empirical formula or quantitative relationship. This is mainly due to the fact that the reaction in question is usually too general, such as a feeling of exaltation, or ease, and has not often been measured as the ability to perform a task, or to perceive or to respond to tests, capable of quantitative expression. Man becomes quickly tolerant to cocaine; from a dose of 1½ grains, where as little as 8 may be fatal, the dose may be increased easily within a month to 20 grains. But man in this regard is peculiar, for animals become more sensitive to regular periodical doses and not less[1]. It is thought that tolerance in this case is due to the same causes as in the case of morphine, viz. increased destruction, but this has never been shown. Time is an important element. "The daily dose is relatively unimportant, and it is far easier to cure a patient who has taken 20 grains of morphine a day for three months, than one who has had only half a grain daily for ten years. The former can be rapidly cut down with comparative ease[1]." Cocaine tolerance is apparently less definite and slower in formation than morphine tolerance—several cases are on record in which 100 grains of cocaine were taken daily[2].

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[1] *Science and the Modern World*, p. 41.

[2] Feldman, "Racial Aspects of Alcoholism," *Brit. Journ. of Inebriety*, July 1923.

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[1] W. E. Dixon, "Cocaine Addiction," *Brit. Journ. of Inebriety*, Jan. 1925.

One would have supposed that in the relief of pain some quantitative correlations would have been forthcoming, but we have to be content with broad statements, such as "this patient was given after an operation for appendicitis, a dose of $\frac{1}{12}$ grain of heroin every night for five weeks. This led to the addiction habit. At first the heroin had a stimulating effect, and as this wore off the dose was increased[3]." The average heroin addict consumes 8 to 20 grains daily and attains considerable tolerance[1]. The caffeine beverages are said to "enable the subject to perform more work" and not to be true addiction drugs because the doses cannot be much increased on account of cardiac symptoms[2].

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[1] Margaret Vivian, "Drug Addiction," *Brit. Journ. of Inebriety*, Jan. 1927.

[2] W. E. Dixon, "Drug Addiction," *Brit. Journ. of Inebriety*, April 1924.

[3] Sir Wm. Willcox, "Drug Addiction," *Brit. Journ. of Inebriety*, Jan. 1924.

(5) *The Stimulus of Alcohol, Tea, etc.*

I do not propose to haggle over words in using the term "stimulant" in this connection for alcohol. Modern scientific investigation seems to have established the fact that it cannot be regarded as a "stimulant" in the true sense, though it has that appearance subjectively, when by narcotising the higher co-ordinating nervous centres it removes the inhibitions on the lower centres, and allows them to act with unusual lack of shyness and freedom from restraint[3].

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[1] W. E. Dixon, "Drug Addiction," *Brit. Journ. of Inebriety*, April 1924.

[2] C. J. Bond, *Brit. Journ. of Inebriety*, Oct. 1922. Also C. C. Weeks, *ibid.* July 1925. Dr Hercod, *ibid.* Jan. 1926.

[3] *Vide* specially *Alcohol* (Medical Research Council), p. 149. Horsley and Sturge, *Alcohol and the Human Body*. *Vide* also Dr Bousfield, "Pathology of Alcoholism," *Brit. Journ. of Inebriety*, Jan. 1926 and Dr Stanford Park, "Inebriety—Disease or Vice?" *Brit. Journ. of Inebriety*, April 1924.

Some go so far as to call it a "purely narcotic drug, and not an excitant in any way," merely relieving states of tension, but others agree with Mr W. E. Dixon of Cambridge that it has "some slight claim to the title of cardiac stimulant[1]." In connection with alcohol, therefore, I refer to this subjective effect of release as if it were true stimulus, for the objective consequences have that character, up to a point. And there is no reason to suppose that the laws governing reaction from artificial depression differ greatly from those applicable to artificial stimulus.

Most experimental tests of alcohol effects stop short at the first result and establish no statistical relations with successive doses and effects, or larger doses and effects, but merely give general ideas. Thus, on the power of alcohol to induce sleep—"At first it provides the desired effect...but the dosage has to be rapidly and continually increased[2]." Some degree of tolerance results from continual use—steady drinkers have been known to take daily

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[1] "Mental states in Alcoholism," *Brit. Journ. of Inebriety*, July 1921.

[2] Sir Maurice Craig, "Alcohol in relation to Mental Disorder," *Brit. Journ. of Inebriety*, Oct. 1925.

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23 ounces of absolute alcohol—"more than enough to kill a neophyte[1]." But this tolerance is different in degree for nerve cells compared with other bodily cells. In any case it is far different in degree from that for other drugs, such as opium and morphine.

Even the precise personal experiments by Dr Vernon have not thrown much light on the problem of continuous doses, though they indicate the progressive diminution of the effect of one dose. For example, from a percentage of 1·6 in typewriting errors before the dose, he got 9·8 per cent. 34 minutes after, 8·0 per cent. 94 minutes after and 5·7 per cent. 134 minutes after. The time taken for chain assembling rose from 382 seconds before alcohol to 455, 50 minutes, and 439, 80 minutes after[2]. Certain small indications of cumulative effects of six daily doses emerged[3]. Totterman showed that skill in threading needles the morning following a dose deteriorated perceptibly after 5 days and materially after 10 days, while 6 days cessation were necessary to reacquire skill[4]. McDougall's experiments were also mostly of the same non-repetition type[1] and exhibited the strikingly opposite effects of *tea*. Contrast between alcoholic and other "stimulants" is made by Horsley and Sturge: "Tea, coffee and cocoa have no depressant after-effect. Their exhilarating influence has no reaction stage to follow, neither do they cause degeneration of the tissues—hence they are entitled to be called 'stimulants'...alcohol has a prolonged depressant after-stage...[2]." Sir F. S. Clouston said "so far as scientific experiment goes, tea is proved not to weaken but rather to stimulate the mental power. Its use in moderate quantity is not followed by any injurious reaction[3]."

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[1] *Alcohol* (Medical Research Council), p. 99.

[2] *Brit. Journ. of Inebriety*, Jan. 1923.

[3] *Brit. Journ. of Inebriety*, Jan. 1922.

[4] *Skand. Arch. f. Physiol.* 1920, p. 107.

Sargant Florence tested the effect of tea upon typists given at 4.15 to 4.30 during afternoon work lasting from 2 till 5.45. On tealess afternoons the last 1½ hours averaged 1·95 lines per minute, but on the others 2·61 lines—an increase of over 33 per cent. There is no record as to whether this advantage tailed off[4]. He records Martin's experiments with heavy and light smokers, but only that the hourly output curve of the heavier smokers falls off more markedly.

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[1] *Brit. Journ. of Psychology*, Vol. 1.

[2] *Alcohol and the Human Body*, p. 90.

[3] *Hygiene of Mind.*

[4] *Economics of Fatigue and Unrest*, p. 263.

The careful records of the Medical Research Council do not throw much light on final reactions or repetitive effects, for they deal mostly with direct results of single doses, with vague references to effluxion of time, *e.g.* Miles also found that the speed of the knee jerk was lessened during the first 2¼ hours after a dose of 30 c.c. of alcohol—subsequently the speed was somewhat increased. Again, 40 minutes after a dose the speed of eyeclosing reflex was decreased by more than 12 per cent., the speed gradually increased till 2¼ hours after the dose it was somewhat greater than normal —it then became less[1].

The Council records Hellster's ergographic experiments: a decrease in recorded muscular work of 20 per cent. half an hour after the dose, 17 per cent. 1 hour and 11 per cent. 2 hours after[2].

A suggestion of *full reaction stimulus* is indicated for alcohol by Dr Collis[3]. In withstanding fatigue "a dose may cause a slight and brief immediate improvement which is usually followed by marked decrease in work accomplished"—in one case 12 per cent. Hellster's ergographic records also showed exact measures of this reaction.

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[1] *Alcohol*, p. 49. [2] *Alcohol*, p. 53.

[3] *Brit. Journ. of Inebriety*, July 1922.

An example of "*special achievement*" by alcohol stimulus is given by Dr Bedford Pierce: "I may here recall a personal experience as illustrating Dutch courage. Once when mountaineering, after an injury to an arm, I ascended without great difficulty an ice-slope in which the guide had cut steps of ample size. On the return journey, however, when exhausted after a long day on snow and rocks, I dared not attempt the ice-wall, and felt I could not possibly lead down it, although the steps were as large as coal scuttles! At that juncture the guide pulled out his flask and I drank the spirits offered. Immediately my mood changed. I had forgotten nothing; it was not a case of oblivion; and I grasped the risks quite clearly; but all nervousness had left me; I knew that I should not slip! In ten minutes the descent was accomplished, though later, at the hut, I was obliged to lie down for an hour, and when I started again I felt unsafe on the ordinary mule track!"

It will be seen, therefore, that the leading from the physiological action of stimulants is very inconclusive in the direction of a generalised principle which can assist us, though analogies may be interesting.

(6) *The Fertiliser Stimulus.*

In the case of fertilisers we may have to complicate the simpler ideas of stimulus. For it may be a new chemical element added to the others, and subject to straightforward usage of the added stock in a quantitative sense; it may be a "release" setting the other elements to work; or an energiser, toning up the whole combination of elements for their task. Sir Daniel Hall writes: "Fertilisers are in some sort conveyors of energy to the plant, at least they make it able to draw upon the unlimited energy of the light reaching the plant. There is no exhaustion consequent on fertiliser action, nothing to suggest that the soil is less fitted to bear a second big crop after the first has been brought about by ample fertiliser."

The results of field tests, which I quote below, are "probably due to other factors than exhaustion consequent on fertiliser action. One is possibly the depressing effect of a given crop on successive crops of the same kind—a very real effect with clover, a probable effect with barley, but small and hardly distinguishable with wheat. The second factor is the accumulation of weeds on these plots, which are set to grow the same crop year after year. Certain weeds which the crop favours become almost unmanageable in time, and I doubt if any of the Rothamsted continuous plots, after the first 30 years, have given returns that may be regarded as the 'absolute' equivalent of the fertiliser." The comparative results only bear discussion.

Experiments in wheat (Broadbalk Field), Rothamsted, showed that, under the annual application of a constant amount of farmyard manure (14 tons) for 61 years, "after a rapid rise during the first eight years of the experiment, when the land was recovering from a state of comparative exhaustion, the yield has been slowly increasing." On the unmanured plot there was at first a fall, and then it became practically constant. The treated soil had accumulated reserves of plant food which it would take over fifty years to "crop out" entirely. The other fertilisers in annual application seemed, broadly speaking, to have big initial effects with a slight tailing off later into a relatively constant level.

Barley crops in Hoos Field showed a continual decline without manure and not a comparatively stable position, while the continually dunged plot has not maintained its yield but has slowly declined. These results indicated that no positive law of exhaustion from successive stimuli can be found in this direction, and merely that the barley crop is far more dependent than wheat upon a supply of manure and particular manures. Mangolds, turnips, potatoes and sugar beet fail to yield any common generalisation. In the case of beans, and hay the deterioration in yield for unmanured and manured lands alike was very marked. The plot 7–1 shows the residual effects of dunging twenty years from 1852–71. One table gives the five-year average yields as percentages of the average yield of the continuously manured plot (7–2) sinking from 75 (1872–5) to 40 (1907–11). Plot 10, which has never been manured, sinks from 25 per cent. to 20 per cent. Although the "crop grown with residues of dung is continually falling it will only reach the level of that on the continuously unmanured plot after a long time[1]." But the effect of potash upon the yields was seriously diminishing or practically constant according to whether ammonium salt or nitrate of soda was the source of the nitrogen used.

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[1] On this Sir Daniel Hall remarks: "The case of dung showing its effect for 20 years and over can most

Certain experiments with "doses" of fertiliser, two, three and fourfold, showed wheat yields obeying the law of diminishing returns, 18·3, 28·6, 37·1, 39 and 39·5, or increases of 10·3, 8·5, 1·9 and 0·5, while the straw results were not dissimilar.

Sir Daniel Hall's summary of my review above is informing: "You can regard an imperfect fertiliser as a stimulant—*e.g.*, nitrate of soda contains N alone and will provoke considerable growth with a consequently extra draft on the stock of phosphoric acid and potash in the soil. Hence with an imperfect fertiliser, by provoking growth that draws from the soil things which are not put back, the yield after a time *might* become less than with no fertiliser at all. I stress *might* because only in

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simply be regarded as a case of slow exhaustion of an initial stock which only becomes liquid by degrees. The best analogy is that of the edition, say, 2000 of a standard book. In the first season perhaps 1000 are sold, next year perhaps 300, less and less each year as the book ages, till in time it is dribbling out at about 20 copies a year, a little up or a little down as some favouring wind does or does not blow."

one case can I trace this to have happened at Rothamsted. Generally some secondary reactions set in. Successive doses of fertiliser do result in increments of descending magnitude (law of diminishing returns). Several other cases have been worked out since the one from Rothamsted that I published. Possibly, however, the curve of increasing production is a sigmoid curve concave at first before it turns over, like Yule's population curve; but I don't think the data available are accurate enough to determine this."

(7) *The Mechanical Field.*

In the field of *metal stress*, there appear to be no real experimental conclusions, or laws defining what may result from a variation, say, of heat treatment, in enabling an increased stress over the normal to be withstood, either (*a*) with continued extra power during the rest of its life, or (*b*) with a reduced or normal stress afterwards to secure normal life, or (*c*) with a subnormal stress afterwards to secure an ordinary life[1].

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[1] *Vide Proceedings of Institute of Mechanical Engineers*, 1922, Sir Henry Fowler, for differences in tensile tests.

(8) *Stimulus in the Physiology and Psychology of Labour Tasks.*

There is a considerable field of enquiry which is of direct economic significance exhaustively covered by Mr Sargant Florence in his *Economics of Fatigue and Unrest*, which records many exact statistical results of variations in working conditions, of the "before" and "after" type, taken in two blocks, and generally without a succession of the effects which would enable one to see whether the improvement is constant, or increasing, or diminishing. A careful study of the field leaves one with the impression, however, that all those differential points which are in the nature of improved conditions of work, *i.e.* increase its "*feasibility*" as the author puts it, act just like an improved tool or new invention would do, and give a constant increment to production.

Belonging to this order of improved conditions I may mention optimum points of temperature, ventilation and of humidity, especially in certain industrial processes; arrangement of spells of continuous work, giving maximum production, minimum fatigue, minimum accident rates, minimum defective work; comparisons of days and night work with similar objects; the accident curve of consecutive hours of work; the effects of overtime differently arranged; motion studies involving a rearrangement of manual movements. Experimental tests may show, too, the optimum load—thus Taylor found that when pig-iron loads were 92 lbs. a first-class workman could only be under load 43 per cent. of his time, and reducing the load improved the percentage, so that the output was increased as much as 276 per cent.

These cases are what I have called "increased scope" rather than any change in incentive, or stimulus, and if they fall within my subject at all they do so only as regards the *stimulus* to discover such short cuts, or improved methods, or physiological reactions. This stimulus may spring from scientific curiosity, in the psychologist; from economic interest, in the effects upon production; from humanitarian motives, in a desire to minimise fatigue, ill-health, or monotony.

When Sargant Florence is discussing the scope of fatigue and unrest and its graduations from positive ill will at one end to ill-health in occupational disease, he likens them to a spectrum in their shading off, a "notion of a kaleidoscope of moods and conditions...facilitating a solution of what may be called the variations in the stimulus imbroglio." He notes that variability of stimulus has given rise to trouble to the student unnecessarily because of its use for two distinct types: (*a*) variations in *external* incentive, such as payment of a higher or lower piece rate or the approach of holidays, and (*b*) variation in the shade of capacity or willingness, *i.e.* in the inward stimulus or intensity with which the human being is working, variations which may or may not be the result of variations in some external stimulus.

The effects of a change of hours upon the economic output are less mechanical and physical, and more physiological and psychological, because the economic motive is more directly affected. Sargant Florence sums up a long examination of available material by declaring "Reduction from a 12 hour to a 10 hour basis results in increased daily output; further reduction to an 8 hour basis results in at least maintaining this increased daily output; but further reduction while increasing the hourly rate of output, seems to decrease the total daily output. These results were obtained mainly in the type of work where the speed of operation depends fairly equally on the human and the mechanical factors. Probably where machinery predominates in setting the pace a reduction of hours would result in less rise or greater fall in output." It must not be forgotten that the final improvement in net output is a combination of better output per hour, less absenteeism, lower accident rates and less defective output. When hours are reduced, the improvement is not immediate, for there is an interval of adaptation, but in the reverse case, where hours are lengthened, experiment showed the decrease in hourly output is practically immediate. Vernon found that a change from 6 to 8 hour shifts put the hourly output down by 11 to 14 per cent.—practically to the old figure.

None of the statistical records throw any doubt upon any improvement of output through reduction of hours being steadily maintained, but they do show that successive equal "doses" of reduction tend to have a clearly diminishing effect. But here one has to consider nominal reductions of hours in contrast with actual reduction. It sometimes happens that a *decrease in nominal* *hours* results in an increase in actual hours of work (Florence, p. 208). We have moved a long way from the time of Senior, when lopping off an hour from 11½ hours labour was matched with lopping off the whole net profit, owing to the great proportion of fixed to circulating capital. Physiologists have claimed that the worker, consciously or otherwise, maintains an equilibrium in energy by balancing application against length of his working day[1]. If 12 hours have to be worked instead of 10, closeness of application will be less throughout the whole, and Vernon suggests an unconscious balancing of pressure to account for the astonishingly steady output of workers in heavy operations.

Sargant Florence in summarising the effects of piece-work rates as compared with time rates, says that they do not afford the proper "incentive" unless certain simple conditions are fulfilled: (*a*) the worker's output must be individually clear and not confused with that of others, (*b*) the system must be clear, and non-proportional rates of increase must not be too involved, (*c*) the worker must not have reason to suppose that his output is being measured for any other purpose—*e.g.* rate cutting, which has so often led to restriction of output. The effect of introducing piece rates has often been statistically demonstrated. The British Health of Munition Workers' Committee, for example, showed that girls on day shift increased output 24 per cent.; on night shift 40 per cent.; in the particular case of re-tapping fuses the increases were 28 and 48 per cent. respectively.

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[1] Kent, *Second Report on Investigation of Industrial Fatigue by Physiological Methods.*

But a combination of time and piece rates has failed to provide such incentive. Vernon (*Industrial Fatigue and Efficiency*, p. 133) showed that riveters with a guaranteed daily minimum had restricted output to a point which at piece rates gave less than 60 per cent. of their minimum pay. When the daily minimum was abolished they nearly doubled their output of rivets.

Florence gives as an "anti-incentive" the fixing of piece rates too high by reference to actual study of the *best* worker or the *best time* of an average worker. There is such a considerable variation natural to men that the error of scientific management in relying on a standard time or standard performance with 80 per cent. or 150 per cent. efficiency is rightly criticised. He mentions as a curious stimulus, piece rate earnings prior to a holiday, which puzzle those who are studying fatigue and must be due to the desire to accumulate a fund for spending. In general the value of "interesting" the worker in the process of production by education, etc. has been often proved, but no statistical correlations are available, because the degree of interest cannot be quantified.

"If the daily output distribution in any operation has a relatively wide dispersion after an efficiency system of wage payment is introduced, this would indicate success in increasing incentive and stimulating the departure of individuals from a common dead level" (Florence, p. 224). Narrow dispersions, skewed negatively, signify deliberate human restriction of output. Skewed positively, after the introduction of selection of employees by test or examination, a narrow dispersion indicates a successful system of selection.

Florence quotes Knoeppel with approval, in discussing the incentive of piece wages. "Each man should see an ideal ahead of him that his mentality can readily comprehend, for just as surely as he attains this ideal, it is automatically replaced by one still higher.

Thus standardisation becomes not crystallisation but evolution." It is very doubtful, however, whether, as a rule, this is true. Just as there is an equilibrium of effort and hours, so there may often be one between effort and standard of living. It has often been remarked that certain classes of workers who can reach their standard with a few days, will be absentees on Mondays or other days. Lord Rhondda, speaking of coal-miners, said: "The better-off men were, the more easily they could obtain the means of subsistence, the less energy they put forward; there was a very considerable diminution in the output per man per annum. On the other hand, when prices fell and wages followed, the fact that the men worked harder accentuated the depression which followed...[1]."

I remember seeing graphs in 1919 and 1920 which showed that although increases in wages had been given, the men did not take full advantage of the increased earning power, and other weekly statistics throughout 1921 showing that the reverse process is also true, viz. that when reductions in wages have been made there is no corresponding reduction in hourly earnings.

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[1] *Statistical Journal*, 1914, p. 174.

General experience has frequently verified the former on broad lines, pointing to a *standard amount* of total earnings, which the worker will exert himself greatly to reach, and will not exert himself greatly to exceed.

In physiology, specific antagonisms have been studied by Sherrington as "reciprocal inhibitions" of reflexes. An excitation by stimulus of one set of muscles is accompanied by a corresponding relaxation of others. This phenomenon has its mental counterparts especially in visual phenomena and attention[1]. In psychology, Spearman says "mental competition" with the law of constant output is well vouched by evidence. "The commencement of any mental activity causes other activity to cease" and *vice versa*. For the law of constant output is thus stated: Every mind tends to keep its total simultaneous output constant in quantity, however varying in quality.

(9) *Experimental Psychology*.

In the field of experimental psychology and measurement of intelligence by correlatives, mental reactions to different stimuli have been measured to some extent, but seldom for reactions to successive applications. Schäfer's experimental subjects, while memorising a sense of colours, were startled by a pistol being fired behind them. A large and measurable loss of memory ensued. With repetition the emotional effect decreased and also the disturbance of memory. Dancing mice learned to select the right opening to secure food, and avoid an electric shock, but they learned it more quickly when the shock was slight, for "though all pain from the shock increases the volition to select the other outlet, yet an excess of pain neutralises this advantage[1]."

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[1] Spearman, *Abilities of Man*.

What the psychologists call "perseveration" has been made to include the following subjects of direct experiment, (*a*) persistence of after effects, *i.e.* the continuance of physiological and psychical impression beyond the real duration of the external stimulation, (*b*) spontaneous recurrence to consciousness of an experience, without fresh stimulation, (*c*) degree of hindrance which the perseverating effect of past mental activity causes to a new one of the same kind[2].

Some experiments have shown that, even

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[1] Spearman, *Abilities of Man*, p. 105.

[2] *Ibid.* p. 298.

after life-long practice, with a sufficient motive, people have surpassed what they had previously regarded as their ultimate physiological limit. Thus four experienced typesetters made a continual series of improvements for the first quarter hour of each day. Spearman says "unfortunately the possible grounds for such improvement are so complex as almost to defy reliable analysis. Not improbably, the most potent factor consisted merely in the overcoming of a deeply rooted *habit*, that of working at a rate which could be maintained with comfort and accuracy for the whole day. Such evidence is far from being decisive in any direction[1]."

Experimental variations of incentive with children have led to very negative conclusions[2]. *Very* great effort—such as is produced by a prize of money—tends only to increase speed at the expense of accuracy[3]. It has some analogy with the bad effect of "pressing" in games of dexterity. Different thinkers vary in their experience as to whether a mental problem of special difficulty is best mastered by means of intense exertion, or whether this militates against success. A class of students were evenly divided upon it. One is reminded of the two opposite modes of thought adopted by Spencer and Mill, and described in their respective autobiographies[1]. Graham Wallas comments on Mill's method of repeating by voluntary effort a high degree of energy until it became partially automatic as a habit. "We can detect in the two statements the chief causes which made Mill's thought, though done by a tired man after or before office hours, more valuable than Spencer's thought, though he gave his whole time to it[2]."

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[1] Spearman, *Abilities of Man*, p. 333.

[2] *Ibid.* p. 333.

[3] *Ibid.* p. 334.

The importance of stimulus to effort, as against a merely passive attitude, has been experimentally proved by psychologists. Nonsense syllable series were learned in one case with 13 and 9 repetitions as against 89 and 100 required otherwise, and subsequent retention was also much greater in the former case. Habit requires more than mere mechanisation—it demands set purpose, and persistence in effort. In the case of telegraph operators, the rise in the "attainment curve" only took place when there was a deliberate attempt to improve, due to strong stimulus, such as desire to secure extra pay[1]. The neural basis of habit is well established. Actual formula for attainment curves have been found and applied. Fox's curve is:

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[1] Spencer, *Autobiography*, I. 399–401. Mill, *Autobiography*, p. 123.

[2] *Art of Thought*, p. 155.

$$t = \frac{k}{(n+p)\,c} + T,$$

where t = time necessary for a single operation, n, the number of the performance, k, p and T constants for subject's capacity etc.

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My survey of what we know about the reactions to stimulus in different fields of scientific enquiry in a quantitative sense, indicates that the extent of precise measurement has been very scanty, and no generalisations are yet possible. But so far as classification is concerned, illustrations can be found in general terms, for every type that I first set out as hypothetically possible. We can carry over into the economic field, no single type or line of thought, and it behoves us, therefore, without vague preconceived notions drawn from doses and drugs, to scrutinise every case of economic stimulus to ascertain its true character, warned by the variety of the findings in the constituent physical, physiological and psychological elements, that we must expect wide differences and vital distinctions. It may certainly be said that we have definite teaching in the psychological experimental field to suggest valuable and positive lines of advance in those economic reactions which follow from stimulus to acquire mental skill, knowledge and improved ideas.

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[1] Fox, *Educational Psychology*, p. 118.

(10) *Economic Stimuli.*

(*a*) *Rising prices.* It is now well known that inflation is an important stimulus to business enterprise, because the equilibrium of division of the product of industry is deranged at least temporarily in favour of the business owner, especially if he is working upon loan capital. Suppose that in a static condition a business man produces 10,000 product units worth 10,000 money units, and pays away the equivalent of 1000 product units to the supplier of raw material, in 1000 money units, 5000 to labour, 3000 to the lender of capital and retains 1000 as his own profit. Now let the money units be multiplied so that the price level rises 50 per cent., and a product unit is worth 1½ money units. Then he receives 15,000 money units for his sales of 10,000 product units, pays away 1500 money units for raw material (equivalent to 1000 product units as before) but for wages he pays the old 5000 money units (now worth only 3334 product units) and to capital 3000 money units (worth 2000 product units) and retains for himself 5500 money units equivalent to 3666 product units. Wage adjustments may soon take place but perhaps not to the full extent, and old invested capital may be tied to him to its permanent disadvantage. His profit is so good that he is stimulated to expand his business at a somewhat reduced price in money units. This can go on so long as the stimulus is received in continually increasing doses. But on its cessation, or still more on its reversal, the reaction is severe. Just as his gains were fortuitously increased by the lag before, now they are diminished or wiped out by the lag in reducing nominal wages. The phenomenon ought, after the past twelve years, to be understood by everyone, but it is still too little realised what disaster a reduction in price level, where other elements are not readily mobile, can work in the economic community.

Now, with considerable breaks, a secular change has been going on in the value of money during the past 500 years, in such wise that business enterprise has continually, but unconsciously, been subsidised by the slow unseen robbery of past accumulations of capital, little felt because so gradual, and because ownership has passed through many generations. A man in the sixteenth century who abstained from consuming 100 units worth £100 in order to enjoy £6 or £7, buying 6 or 7 units, per annum, has been succeeded in ownership by a descendant who may get the same £6 or £7 but it may now buy only half a unit, owing to the continual depreciation of the monetary unit. These twilight death duties have always hit the owner in possession. As a matter of fact, of course, no such continuous ownership of mere monetary titles has existed because redemption reversions and terminations of one kind and another have affected probably every individual case. But the secular stimulus has been a fact all the same.

(*b*) *Changes in demand*. The literature of economics on fluctuations abounds in the use of the words "stimulus" and "stimulate" and their synonyms or variants. Thus: "Demand for a product being elastic, a rise in its real costs stimulates a curtailment of output on the part of other industries, and ...the demand for a product being inelastic, a fall in its real costs stimulates a contraction, and a rise in its real costs stimulates an expansion of output on the part of other industries[1]." Here the word shades in meaning from "tends to promote" up to "necessitates," according to the degree of friction postulated. It is very much as if one said "Let three balls of different weights or sizes be resting on the bottom of a bowl —the removal of one of them will *stimulate* a change in the position of the other two."

(*c*) *Taxation.* I do not pretend that the distinction between the two meanings of stimulus is always clearly marked, and often both are present, for the enlarged scope itself may give zest to a jaded incentive. A good example is the *stimulus* given to saving by a substantial relief in supertax. A man with £10,000 a year has been spending say £6000, saving £1500 and paying £2500 in tax. Now his tax is reduced, say to £1000. There is an impetus to saving because the fund available for saving with the same incentive per £ of saving has increased from £1000 to £3000. But the net reward for savings, due to the lighter tax on the income to be derived, and the larger sum to be retained, mean that each £1 is much more worth saving. Both scope and incentive are increased, so that there is a stimulus to saving in both senses.

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[1] Robertson, *Banking Policy and the Price Level.*

(11) *Classification of Economic Stimuli by results.*

Throughout the literature of the enquiry into industrial fluctuations, the successful upshot of which means so much to the future of civilisation, the ideas of automatic scope and motival impetus are confused under the one set of terms. Again, even where the terms "stimulus" and "stimulant" are confined to the latter sense, they are used to cover two influences of highly different consequences. It is natural to rejoice when some factor improves business. But if it is a factor that inevitably entails a reaction, even an equivalent loss, how different it is from a factor which will permanently raise economic life. What we really want to know of any encouraging stimulus is its ultimate effect as class A or class B or class C.

For example, let me take one quotation from Professor Pigou's latest book, *Industrial Fluctuations*, p. 102, where he is dealing with the relative demand for instrumental and consumption goods. "Thus, the upward fluctuation of industrial activity above the normal *carries with it* a subsequent downward fluctuation below the normal when the stimulus is removed, and not merely a subsequent return to the normal." In other words a perfect illustration of stimulus Class B 2, "*Status quo*—full reaction."

How can we go on accepting with uncritical satisfaction every factor that makes for better business as though they were all alike, when some bring their own nemesis? Or with indiscriminate depression every factor that makes for bad trade, when some are generating their own reaction?

On a broad view, I should say that the monetary factors in fluctuation, however stimulating, are nearly all of the self reaction type, and what one gains on the swings today is lost on the roundabouts tomorrow. If they are very severe they belong also to type "C" and actually lower the tone of industry. Thus, with labour suspicious of capital, a perfectly justifiable attempt to adjust money wages downwards to secure that real wages do not advance too fast for total production, may bring about prolonged labour disputes and exasperation, with ca'-canny and other anti-economic policies for output in the future, when the crisis need never have taken place at all if monetary fluctuations had been kept within narrower bounds. On a broad view, again, I should say that psychological causes of industrial fluctuations, including mass miscalculation of production and demand, tend to be of the B 2 type, varying towards C 2.

But the stimulus of a bountiful harvest, with the enhanced purchasing power it may afford, tends to be of the simple B 1 type (*status quo*—single gain). On the other hand, a clever reduction of costs through reorganisation, or a definitely better motive stimulus to work harder or more efficiently, belongs to the A 1 class.

But these are only broad generalisations, and we need some running scientific analysis in popular thought upon economic life in general, to create a technique of discrimination.

(12) *The Value of Rhythm.*

It must not be supposed that the elimination of the monetary factors in trade fluctuations would produce an absolutely level and predictable course of business, in which the only reason for good or ill fortune by individuals would be the competition of their varying individual merits or the differences in their physical equipment. In the first place, price level control by banking policy could never be exactly effective, and its minor errors of judgment must inevitably set up irregular movements with a definite, if more limited, range of fluctuation. Secondly, those naturally variable or unpredictable phenomena, such as aggregate world harvests, the content and life of mineral properties, and the vagaries of human fashions, must always provide elements of uncertainty giving periodical jerks to an otherwise even progress of events. In the third place, as D. H. Robertson points out[1], an alteration in the operating costs of one industrial group may indicate a situation in which other industries have a reason to expand (or contract) their output. " In particular, a lowering of the cost of production of basic constructional materials may constitute a natural incentive to the expansion of output on the part of pretty nearly every trade." His general conclusion is that "even in the simplified industrial world which we have constructed we should not expect the appropriate or optimum rate of industrial output to be constant, but to be subject to a succession of what may be called 'justifiable' increases and decreases, some at least of which are of a fairly rhythmical nature."

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[1] *Banking Policy and the Price Level*, p. 16.

So far as concerns agriculture—an industry which is clearly a basic element in economic activity—all efforts to reduce its records to a rhythmic rule have so far been baffled. Sir Wm. Beveridge's great attempt at establishing various overlapping harmonic series is said by some mathematicians to be little different from results which might be obtained by harmonic analysis from a random series of numbers. But if all other natural elements in economics were entirely static, it is probable that the human element is in itself rhythmic.

Small fluctuations may belong to a larger system which includes others of longer duration. Steady pulsations in mental output, like temperature from moment to moment, go on irrespective of larger and seasonal changes[1]. These oscillations tend to have such constancy or stability as to be rhythmic, finding an ultimate physiological basis[2].

Is it not likely, however, that a quality essential to the individual will have cumulative effects in the mass in large numbers? It would rather be expected that the "heights" of one-half would coincide in point of time with the "depths" of the other half of the workers, and make for stability in the mass, or that individual differences are like that dashing and colliding in all directions by which "solidity" results from the perpetual motion of atoms.

The question whether in the long run the economic advance to be secured under conditions of stability or rhythmic and predictable fluctuation, will be greater than under those of more violent and incalculable change, probably resolves itself into a contrast between the advantages of a perfect development of existing economic institutions, and the advantages of radical improvements and increments of revolutionary change from the gross value of which have to be deducted the losses and disadvantages of disturbance and destruction in human and physical or invested capital. Thus, if a manufacturer were quite sure of his market and ran no risks of obsolescence, he would devote himself, without danger to his capital, to investment in quite small benefits of reorganisation and oncost adjustment, and he would bring the productivity of existing methods and machinery to a high pitch of perfection. But if he is never certain that a new process and deranged demand may not upset his calculations, it is worth while risking capital only upon large marginal gains, and such are provided by great changes which increase gross product in a striking degree. But obsolete plant has to be amortised and displaced human skill has to be supported and transferred, so that large deductions must be made from such gains, before the net progress is ascertainable or comparable.

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[1] Spearman, *Abilities of Man*, p. 321.

[2] Bayliss, *Principles of General Physiology*. Fox, *Educational Psychology*, Chs. x and xii.

For cycling as an interesting and pleasurable pastime, maximum advantages were not, in the long run, gained upon absolutely level surfaces, exhilarating as an initial burst of speed may have been. Neither would one for long find pleasure in a road with alternating rise and fall of identical extent and scenic sameness. Nor was a series of breakneck descents and unrideable ascents conducive to a successful tour. A mixture of compassable difficulties and balancing ease, of surprise and variety, but all within the compass of safety and of the limits of rest and refreshment which are normal to man, provided the optimum satisfaction. So with economic progress serving human happiness. But Hamlet's "How weary, stale, flat and unprofitable seem to me all the uses of this world" anticipates my association of flat cycling and economic profits. Too violent or rapid change may stretch the elasticity of the fabric beyond its critical point, so that it may fail even to rebound or react. It may deprive the medium of its essential tone or quality, like an overweighted spring, or an overstretched elastic. Within a critical point rebound is certain and the nearer the critical point the more rapid, but beyond it is disrepair with perhaps a slow recovery of tone. Something of this order of stress has come upon some basic British industries as a result of the extraordinary violence of economic change since the war. As Professor Whitehead says, "There is a degree of instability which is inconsistent with civilisation. But on the whole, the great ages have been unstable ages[1]."

The object of controlling monetary policy and the price level is not really to flatten out economic life into a dead level, but to ensure appropriate and ready reaction to changes in output, and to act as a governor so that those changes shall not be cumulative and amplified, and especially that they shall not pass beyond the critical or test point, beyond which the swing is not back to equilibrium, but goes on to complete overturn. This, moreover, is quite a different policy from that advocated by those who would continually create purchasing power, and *in advance* of production, as an artificial lure which could be indefinitely repeated without disadvantageous reaction, a continual goad to the price level, a perpetual promise of greater real gains than can ever mature. But the economic donkey with his nose a fixed distance from the economic carrot tends either to overrun his strength, or discover the illusion.

It is impossible to be dogmatic about a higher rate of wage being a stimulus to the whole organism, without studying the conditions. If it makes possible a physical condition in the worker which creates an ampler output from which the wage can be derived, and is in the first instance a bridge of hope, then obviously it is an all-round betterment. If it deranges the rewards of other factors of production, it may well defeat its own object. Even, in itself, it does not always make for a higher total wage, but only or partly for less work time. If leisure is wisely spent even the latter may be economic gain, but it is not a postulate that is often safely made.

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[1] *Science and the Modern World*, p. 259.

That a given real reward is, in any absolute sense, requisite to call forth a given effort of body or mind is manifestly fallacious. Men quite happily worked just as hard for half the real income two generations ago. They obviously work just as hard for half the real reward in one country compared with another at the same moment. The standard of life, and the living wage, the motive of adequate profit, are all relative conceptions, governed by comparisons in juxtaposition for time and space. The bearing of this on heavy taxation is obvious. It "depresses production" and so on. But even the net real reward, after bearing the dreadful burden, is far greater than it used to be in days of lighter taxation.

Immediate changes of taxation may be

potent, but tolerance both ways is extraordinary. The usual budgetary season assurances make out that if the Chancellor would only take a shilling off the income tax he would so stimulate trade as to more than make good the loss in the rate by the volume of the assessment. I have shown elsewhere that, with maximum postulates, the real effect is unlikely to exceed a recovery of 2*d*. in the £ instead of the whole 1*s*. in the first instance. In later years increased scope will make the effect cumulatively greater, but this is probably offset by the deadly effect of either tolerance or exhaustion in toning down stimulus.

(13) *Discrimination in Stimulus.*

It is time to consider briefly the positive stimuli of the A 1, or Full Permanent Gain, class, upon which economic progress really depends. The first is any stimulus to overcome the conscious effort of a new or difficult way of working, physical or mental. Fortunately, repetitive stimulus has the characteristic of setting up habit. William James said an effort repeated thirty times became a habit, and habit, said the Duke of

Wellington, is not second nature, but ten times nature. James calls habit the "enormous fly-wheel of society, its most precious conservative agent[1]." May I say also that it is its most revolutionary agent? For men may reach a pitch of performance in one effort, and have no permanent effect on progress, but let them repeat it to the point of habit and it becomes a new level of regular economic performance. Now it is not merely the stimulus Class B that would otherwise sink back to normal if not repeated, but also stimulus Class C with its positive reaction that may bring about a permanently higher level by repetition at sufficiently frequent intervals before the reactions have set in. Thus James says that without repetition, "it works so as positively to hinder future resolutions and emotions from taking the normal path of discharge." In the realm of general thought and average mental ability the repetition stimulus is most important, and the distribution of repetition is equally important. Thus matter read five times in one day compared with once every day for five days, gave almost equal results in memory the following day, but after two weeks' interval retention was 13 per cent. in the one case against 37 in the other, and after a month 11·5 per cent. against 30·5 per cent. in favour of the daily exercise[1]. The stimulus of an intelligible meaning to the matter learnt makes repetition remarkably economical and greatly lowers the number of times it is necessary to re-read. Sixty words were learnt with 6 repetitions and 750 with 19, where 36 non-related words took 55 and 33 repetitions for two practised learners[2]. The whole field of experimental educational psychology abounds in instances of the scientific study of repeated stimulus in permanently raising mental power.

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[1] *Psychology*, 1893, pp. 142–150.

In the higher field of conscious creative thought, which is the line of greatest promise for the progress of the world, the laws of stimulus and its application on lines of permanent advantage are only just beginning to be understood. "The education of the will by forming stable habits of action in new directions is a creative act in that it implants in the individual life new sources of energetic impulse[1]." Graham Wallas has well analysed both the value of habit and its snares. First, comes the permanent power derived from a repeated time stimulus, starting intellectual work at a particular hour daily, so that "warming up" occurs rather more easily and quickly. Second, there is the value of particular sensory stimuli, such as furniture and ornaments arranged in a certain order. As against this, too set a habit in point of time may deaden really creative thought. "Every thinker must remember always that if he is to get any advantage from the fact that he is a living organism, and not a machine, he must be the master and not the slave of his habits. He may find it best to sacrifice some of the advantages of habit in order to strengthen the factor of stimulus by beginning work at dawn and going for a walk at 11 a.m.[2]" Descartes "got the most fruitful stimulus of his life by going on a short campaign. This antinomy between the stimulus of habit in time and place and circumstance, and the stimulus of breaking habit, is constantly reflected in the lives of those who are capable of serving mankind as creative thinkers." It does not follow that the habit breaker must in itself be a highly significant incident. "Almost any idea which jogs you out of your current abstractions may be better than nothing[1]."

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[1] S. D. Austin, *American Journal of Psychology*, 1921.

[2] D. D. Lyon, *Journal of Educational Psychology*, 1914.

The contrast between small injections at frequent intervals, and those larger ones where reaction has time to set in has never been worked out. A friend of mine finding that large scale daily deep-seated injections for diabetes were causing wide fluctuations of pituitary activity above and below normal, substituted frequently repeated insufflations which kept the activity relatively level and above normal, and was shortly able to stop the treatment altogether for some months. But a layman's experiment has received no professional recognition yet, and I suppose I must not call it scientific.

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[1] Fox, *Educational Psychology*, p. 111.

[2] *Art of Thought*, p. 148.

Graham Wallas is full of suggestive reflections upon the increase of mental energy. He says wisely that, in the art of thought, as in other arts, the efficient stimulation of energy does not depend merely or even mainly on either the intensity or the repetition of the original effort. The thinker must also learn how to make that particular kind of effort, that particular "stroke" which will bring the energy of his organism most easily and most completely to bear on his task. "Natural thinkers like natural cricketers, may learn it for themselves[2]."

Discussing Dr Adrian's views upon the connection between physiology and mental energy, Graham Wallas says, "There may be those now living who will succeed in

[1] Whitehead, *Science and the Modern World*, p. 77.

[2] *Art of Thought*, p. 153.

relating our inexact and empirical observations of the effects of emotion and habit and action on the success of our thinking, to those measurable facts as to the energy of the nerve cell. If that happens the art of thought may be helped and extended by knowledge of such things as the conditions of cell nutrition, and the influence on living tissues of stimulation by sunlight or glandular secretions."

I do not wish to embark upon the question of heredity in facilitating the formation of habit. But in the case of the experiments with mice to which I have already referred, Pavlov found for the succeeding generations 300, 100, 30, 10 and 5 repetitions adequate for the formation of well-established habits of response. As Fox has remarked, "The case for the inheritance of acquired characteristics is not so desperate as some biologists suppose[1]." Certainly if added to the progressive development of successive environments, the outlook is a good one.

Necessity may be the mother of invention, but in her poverty she can afford very few children and birth control is a real corollary.

Times of depression are indeed a forcing ground for reorganisation and the elimination of non-essentials, but apart from small ingenuities, in a time of abundance of resources alone can large scale inventions and improvements be undertaken. We may then declare that Prosperity, not Necessity, is the mother of invention. In the United States today, every kind of invention or improvement can be lavishly employed even though only a small percentage comes to final fruition, whereas in a poorer country only those changes of proved worth, of large marginal improvements, and of moderate cost can be undertaken. "To him that hath shall be given." The extent to which such prosperity will bring its own reaction in luxury, weakening the fibres of enterprise and application, must depend greatly upon the moral calibre of a people.

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[1] *Educational Psychology*, p. 34.

When one realises that a remote thought, seized by immense effort and brought into the light of full consciousness and experiment by a single thinker, may raise the standard of life of millions more than the discovery of a new mineral field, or the acquired skill of a multitude, can do, one sees that the development of an art of consciously stimulating creative thought on best lines may be the greatest impulse to economic life.

The consideration of creative thought and of invention leads me to say that the stimulus of body or mind which brings with it the severest reactions is nevertheless not necessarily unworthy or valueless. It may be of the highest service. Granted even that the "rum ration" succeeds its period of exhilaration by an equal period of depression, if the job in hand is the vital one of "going over the top"—a job of definite and vital significance and success, who minds what the aftermath may be? I quoted when dealing with *Alcohol*, an example of what I have termed "*special achievement*" by alcohol stimulus. The parallel is equally found in every type of energy stimulus, but its value lies in its rarity and freedom from abuse, its reservation to the truly critical and supreme necessity. If on reaching the apex of the stimulus curve, lifted to that height, a glimpse is caught of an undiscovered world, an unsuspected truth or fact, who minds the B 2 curve of full reaction? If a man by intense and dangerous stimulation of physical and mental powers can break into a new field of human possibility, and reveal it to the world, is he likely to make nice calculations of the prostration of the morrow? Everyone must have had periods in his life when a spurt was worth, in its results, any possible personal consequences, when he might do for the super-normal what he would never attempt daily for the normal. Even the lethargic, who can see a great opportunity, and when it is seen rise to it with unstinted power, may be one of the world's greatest benefactors. It is otherwise, indeed, where

> The slippered hours their placid business ply,
> *And in thy hand there lies occasion's pearl,*
> But thou art playing with it absently,
> And dreaming, like a girl[1].

(14) *Conclusion.*

My study of stimuli has been mainly a search for their later effects, and a plea for discriminating emphasis upon those which really lift the economic life. But I have not here studied the motives and causes of stimulus—the kinds of incentive in which increment is possible—the prides, passions, ambitions, sympathies and ideals of men. Sargant Florence in discussing Wagner's famous five main classes of motive[2] says "the cash nexus is the chief bond between the worker and his work, and other possible forms of incentive, the hobby nexus, the duty nexus, and fame nexus lie neglected." It is a field too vast, and even mysterious. A man may be running "all out" for a £100 prize. In the last lap if it were shouted to him through a megaphone that the prize was doubled, he probably would and could do no better. But a dash of cold water or a burst of cheering might stimulate him to even greater exertion. In the Irish Rugby international, Arthur Young played for all that was in him. He got some cuts on the head during the game, went off and had it bandaged. After that he played like one possessed. There are the ultimate bases of incentive which seem to lend themselves to different degrees of excitation, as Kipling knew:

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[1] A. Y. Campbell, *Animula Vagula.*

[2] *Economics of Fatigue*, p. 73.

If you can force your heart and nerve and sinew
  To serve your turn long after they are gone
And so hold on when there is nothing in you
  Except the will which says to them Hold on,

—a great recognition of the unexpected reserves of energy that are only drawn upon by emergency.

The economic response may conceivably be attained by new or substituted incentive, in which the laws of increment may differ. The stimulus along the wage incentive may conceivably have one kind of reaction, whereas that to the fame or hobby incentive may have quite another. It may thus be possible to get a permanent gain to stimulus by changing the form of the incentive. Physiologically, the reactions to substituted stimulus have not indeed shown this, but there is frequently no exact parallel between the physiological and the mental[1]. Again, in a different environment all our findings may alter. Professor Whitehead instances the new mentality of the past three hundred years, which is "more important than the new science and the new technology so that now the *old stimuli provoke a new response*[2]." In an environment with a higher sense of duty or a different ethical bias, the response to an extra-profit stimulus, or to a higher wage stimulus, may be entirely different.

Probably these subjective bases of economic life differ less amongst masses of mankind at one time or across the ages than the manifold objective manifestations of that economic life itself—

> We see by the light of a thousand years
> And the knowledge of millions of men[3].

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[1] Watson, *Psychology*.

[2] *Science and the Modern World*.

[3] *Engineer*, 12th Jan. 1900.

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